Mediterranean Storms

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EDITORIALE BIOS

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Mesoscale convective systems during 1990-94: characteristics and synoptic environment

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ABSTRACT

Mesoscale Convective Systems (MCSs) data registers from June to December during 1990-94 were obtained from the Spanish National Meteorological Institute (INM). Sixty seven Mesoscale Convective Systems (MCSs) and fifteen Mesoscale Convective Complexes (MCCs) were identified through this database. Most of the MCCs and MCSs developed during the last week of September. The dominant synoptic patterns related to the mesoscale systems were cold fronts at the surface with warm and moist low-level cores, and cut-off low or deep trough throughout the middle and upper levels. These synoptic patterns were found in all the cases studied.

The hourly centroid location of the MCC was used to trace their tracks, which followed a general direction towards the E or NE in almost all cases. These trajectories are clearly related to the synoptic patterns found. Finally, a Skew T- Log p thermodinamic diagram from the nearest sounding station to a developing MCC is shown.

1 INTRODUCTION

In the first days of Autumn, intense precipitation over the Mediterranean area of the Iberian Peninsula and the Balearic Islands are frequently registered without an exact periodicity.

These intense storms originate flash floods that cause important damages to property and loss of human lives.

These mesoscale systems are not only characteristic of the western Mediterranean area.

Their origin is clearly convective, having features in common with the Mesoscale Convective Systems (MCS) and Mesoscale Convective Complexes (MCC) described by Maddox (1980). Summaries of MCS and MCC characteristics have been published (Maddox et al. 1982; Rodgers et al. 1983, 1985; Augustine and Howard 1988, 1991). These papers are centered mainly on the MCCs observed in America and some locations in China, even though Augustine and Howard (1991) mentioned these special convective structures in Hungary, Austria and Yugoslavia.

This work provides a climatological information of the MCSs and MCCs occurred during 1990-94 over the Iberian Peninsula and western Mediterranean area.

The synoptic patterns related to their genesis and development are identified. The track of each MCC has been computed. Finally, some information about the physical phenomena involved in their evolution is presented.

2 METHODOLOGY

The analysis has been centered on the MCS and MCC observed over the western Mediterranean area from June to December during 1990-94. According to the INM historical data, the intense precipitations caused by the convective systems are observed mainly from June to November, and specially during the months of September and October. METEOSAT and NOAA infrared (IR) images were obtained at the INM.

The reports of the convective systems characteristics published by Canalejo *et al.* (1993, 1994), Carretero *et al.* (1993), Martin *et al.* (1994) and Elvira *et al.* (1996) will be used to characterize the evolution of the convective systems. Both, images and reports, will be used used to identify and extract information on MCSs and MCCs.

The MCS and MCC criteria and key definition (Augustine and Howard, 1991) used in this work are given in Table 1. As pointed out by Augustine and Howard (1988) and McAnelly and Cotton (1989), the area within the single colder threshold proposed by Maddox (1980) adequately defines the life cycle, while the use of the second criterion (the use of the -32° C threshold) is redundant and introduces ambiguity.

Criteria:	Mesoscale Convective Systems (MCS)	Mesoscale Convective Complexes (MCC)
Minimum size	CCCS (IR temperature≤ -52° C) must have an area ≥ 10 000 km^2	CCCS (IR temperature ≤ -52° C) must have an area ≥ 50 000 km^2
Duration	Minimum size must be exceeded for a period ≥ 3h	Minimum size must be exceeded for a period ≥ 6h
Shape	Minor axis/major axis is ≥ 0.7 at time of maximum areal extent of the -52° C continuous cloud shield (Only for MCC)	
Initiation	Time when minimum size is first satisfied.	
Maximum extent	Time when the CCCS (IR temperature ≤ -52° C) is at its maximum size.	
Termination	Time when minimum size is no longer satisfied.	

Table 1. Definitions of MCSs and MCCs based on enhanced IR satelite Imagery (Augustine and Howard, 1991). CCCS: Continuous Cold Cloud Shield

Once the convective systems have been identified, the synoptic patterns related to their life cycle will be determined from the surface, 850, 700, 500 and 300 hPa levels published in the INM daily meteorological bulletins. The hourly geographical coordinates of the -52° C centroid area will also be plotted on maps to set the tracks of each one of the MCCs identified. The trajectories will allow us to determine several characteristics, as the direction followed by the systems or the physical processes involved in their life cycle. Finally, a skew T-Log p thermodynamic diagram of the nearest sounding station will be plotted for a MCC. Thus, the thermodynamic structure of storm environment will be analyzed following a methodology simmilar to that used by Keenan *et al.* (1994), Bringi *et al.* (1996) or Alberoni *et al.* (1996).

3 Results

Satellite images and related data from June to December from 1990 to 1994 were used in the present analysis. Applying the characteristics of Table 1 to the IR images of 82 mesoscale convective systems detected during 1990-94, 67 of them would be classified as MCSs and only 15 could be classified as MCCs (Cana, 1997).

The time distribution of these phenomena (Fig. 1) shows that most of the MCCs were developed between September and October. The last ten days of September registered 60% of the MCC (Fig. 2). The annual time distribution shows an asymmetric distribution for the analyzed period, with a non uniform interannual variability. In order to explain these remarkable variations, the synoptic patterns related to each MCC have been analyzed. For all the identified MCSs and MCCs during 1990-94, two synoptic patterns have been detected.

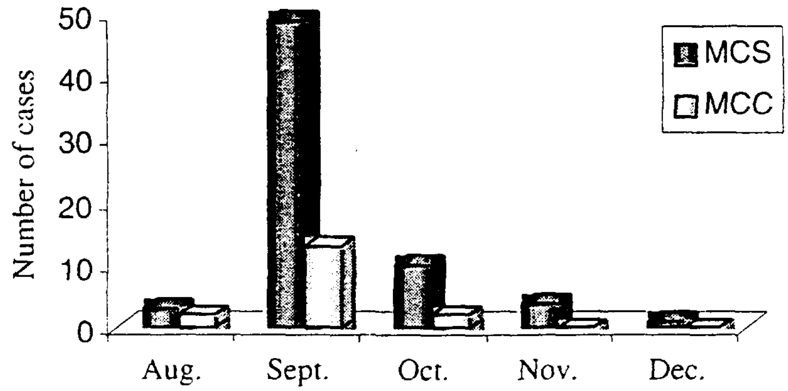

Figure 1: Time distribution of MCSs and MCCs during 1990-94

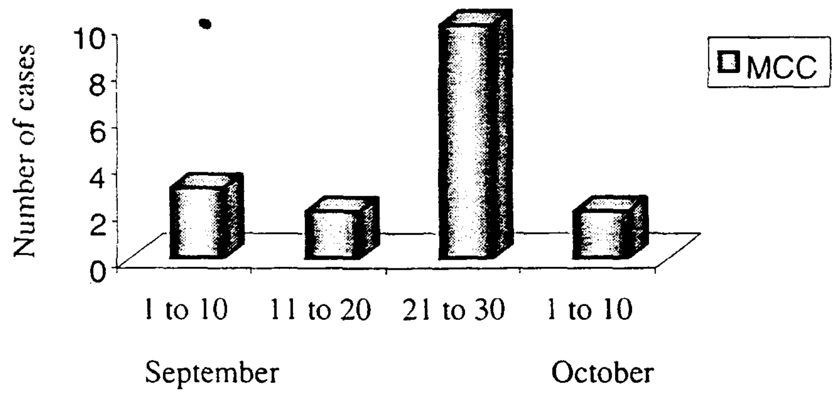

Figure 2. MCC distribution during 1990-94

The first one (Class 1) can be characterized by a 500 hPa and 300 hPa standard level trough, and a cold front related to a low at the West or over the Peninsula at the surface level (Fig. 3a, 3b) . Usually a 300 hPa jet is also present on the life cycle of the MCC. This situation originates prefrontal MCCs. The trough is the most significant element of this pattern, with a N-S or NE-SW axis. A thermal wave reaching frequently -24° C at 500 hPa can be identified together with the trough. A similar pattern has been reported over the United States, where both the trough at 500 hPa level and the presence of a cold front at the surface, have been mentioned (Loherer and Johnson, 1995).

The second meteorological pattern (Class 2) can be characterized by a cut-off low at 500 hPa and 300 hPa levels. At surface, the North Africa low (usually over Algeria) is accompanied by a high pressure area at the West of the

Peninsula and a second one over Central Europe or South of the U. Kingdom (Fig. 4a, 4b). The main characteristic related to this pattern is the genesis of high pressure and low pressure areas isolated from the general circulation. The cut-off low usually presents a cold core (between -16° and -24° C).

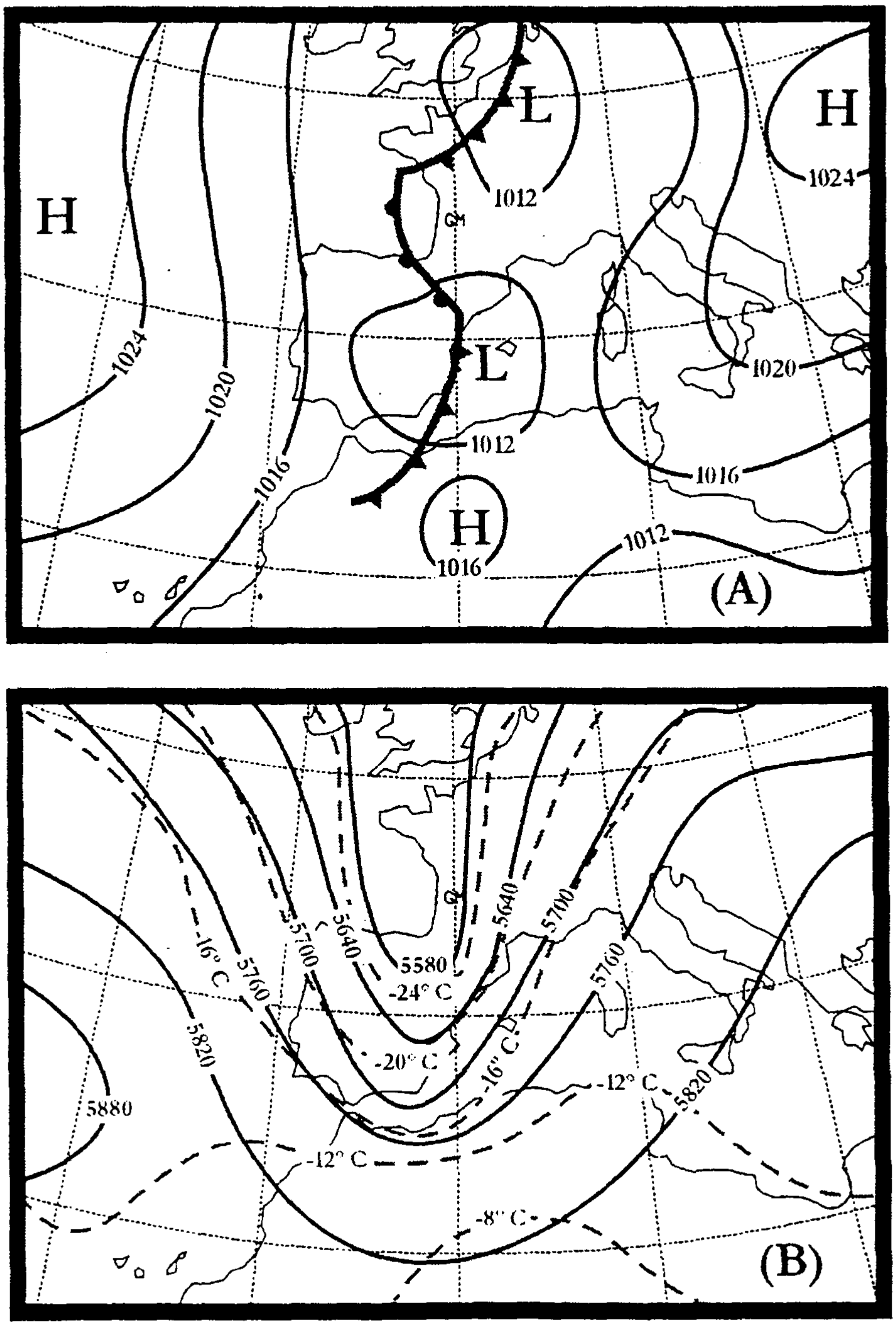

Figure 3. Schematic represention of the two categories found. Synoptic pattern scheme for Class 1. A) Surface level, B) 500 hPa level

The existence of a jet in the proximity of a developing MCC has been verified in 70% of the registered MCC cases over the Iberian Peninsula during 1990-94 (Cana, 1997). The relation between convective systems and jets has been discussed for several cases in the U. S. Great Plains, which has been described by Keyser and Johnson (1984) and Ucellini (1986). The study of the synoptic patterns for the analyzed period shows that the presence of the above described patterns, is a necessary condition, but not enough, for MCC development.

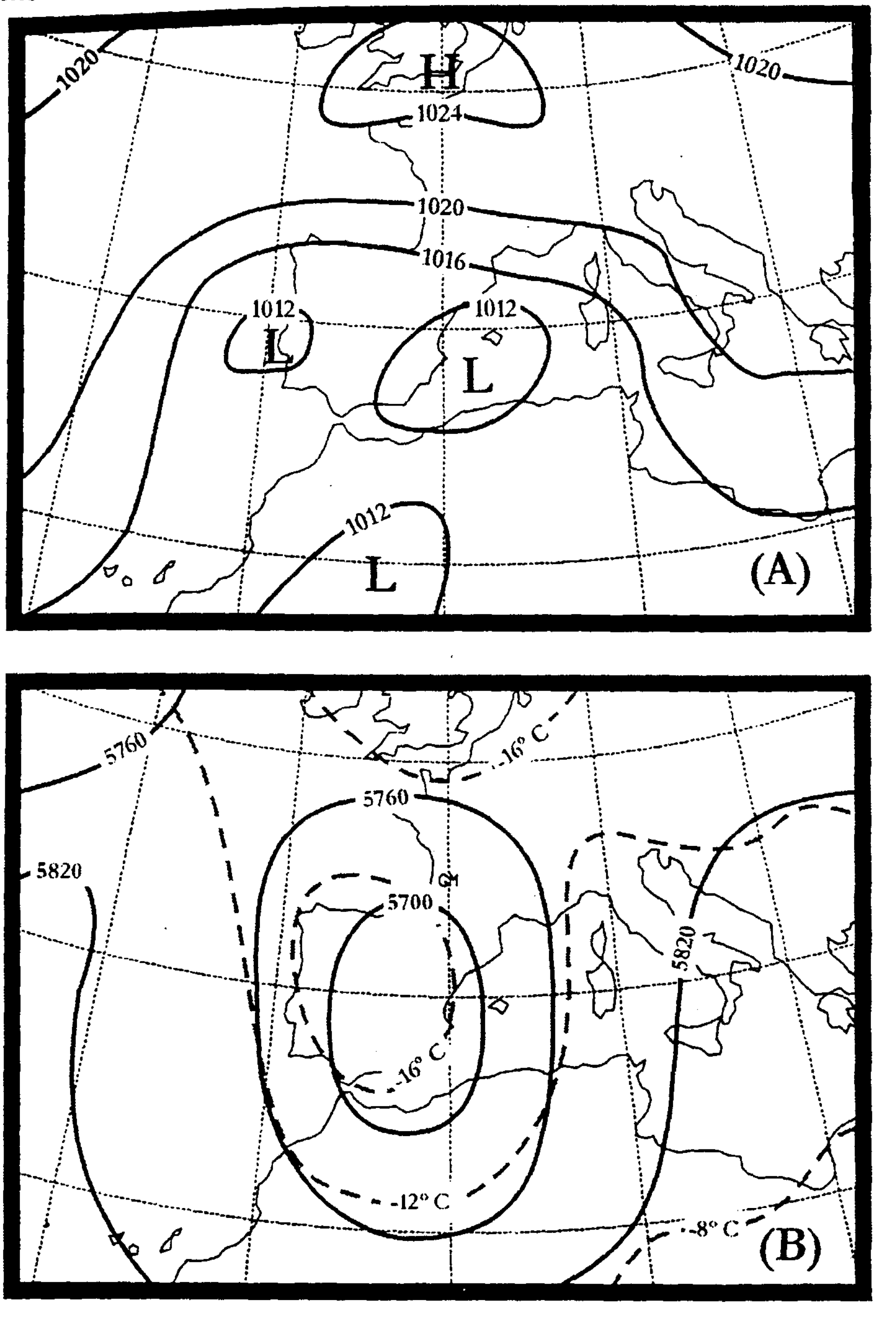

Figure 4. Same as Fig. 3 except for Class 2.

The tracks of each one of the MCCs define two different groups related to the genesis and evolution of the MCCs (not shown). The first one generates and develops near the coast or over the Mediterranean sea, following a eastward or northeastward path. The second group forms over the interior of the Iberian Peninsula, evolving to the interior of the continent and following similar directions. Both groups follow geostrophic trajectories moving to the right of the 500 hPa flow level, a conclusion in agreement with Miller and Fritsch (1991). The analysis suggests at least two different physical processes involved into their development: the instability of overheated air masses from Africa crossing over the Mediterranean sea (Hernández *et al.*, 1987), and the orographic forcing that implies an air-mass ascent (Cana, 1997). In order to show this feature, the skewT - Log p plot for the 26/9/92 MCC is shown.

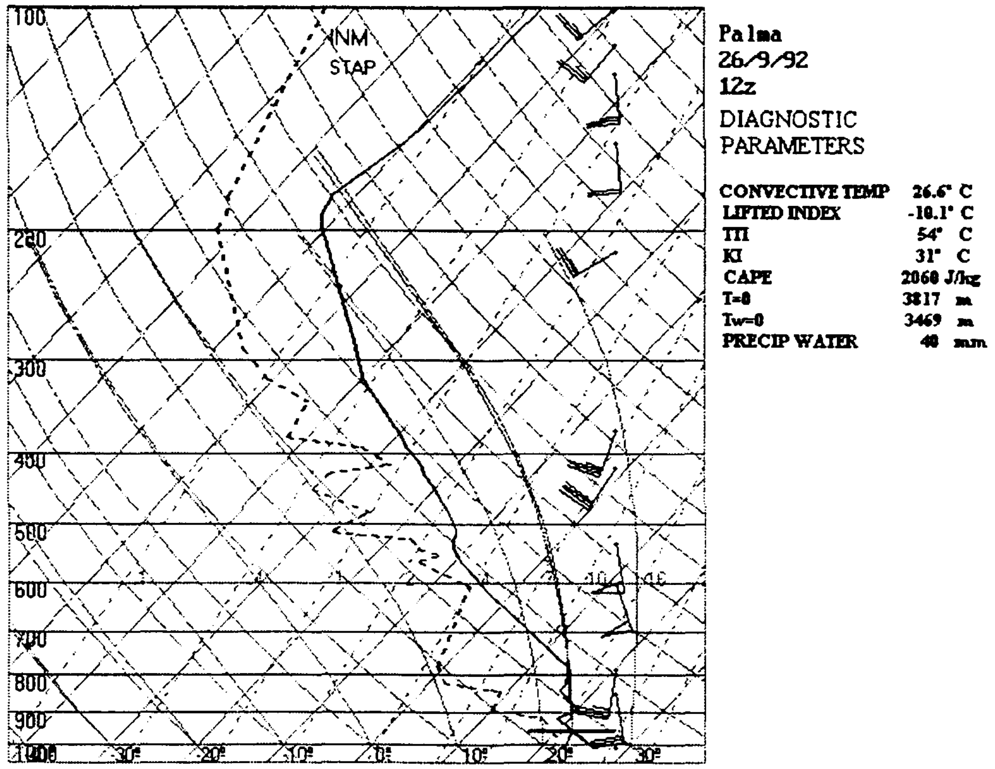

Figure 5. Skew *T* - Log *p* plot of the sounding taken from Palma de Mallorca station on 1200 UTC, 26 September 1992. Full barb is 5 m s^{-1}.

Unfortunately, there are no sounding stations close to the affected area, so the sounding from Palma de Mallorca sounding station (Balearic Islands) at 1200 UTC has been used. It shows a SE flow on the low level layers of the atmosphere (Fig. 5), bringing the necessary humidity to the MCC genesis (17.5 g kg^{-1} mixing ratio and 26.2° C on surface, 8.6 g kg^{-1} and 16.0° C at 1500 m height). From this level, there is a 13-18 m s^{-1} southerly flow. A remarkable characteristic of the Palma de Mallorca sounding is the evolution of T and Td from the surface to the 300 hPa standard level, which presents a low temperature (-42.3° C). The convective indexes reflect favorable conditions for the convection (TTI, 54° C; KI, 31° C; LI -10.1° C). The Convective Available Potential Energy (CAPE) at 1200 UTC was moderately high (2060 m^2s^{-2}), with a total precipitable water content in the sounding of 40 mm.

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